



Environmental Effects of Dredging Technical Notes



INTERIM GUIDANCE FOR PREDICTING QUALITY OF EFFLUENT DISCHARGED FROM CONFINED DREDGED MATERIAL DISPOSAL AREAS--TEST PROCEDURES

PURPOSE: The following series of technical notes describe the functions necessary for predicting the quality of effluent discharged from confined dredged material disposal areas during dredging operations.*

EEDP-04-1	General
EEDP-04-2	Test Procedures
EEDP-04-3	Data Analysis
EEDP-04-4	Application

The guidance was developed as a part of on-going research conducted under the Long-Term Effects of Dredging Operations (LEDO) Program. Procedures for such predictions are being refined and verified under LEDO through comparative evaluations of predictions and field measurement of effluent water quality.

BACKGROUND: Confined dredged material disposal has increased because of constraints on open-water disposal. The quality of water discharged from confined disposal areas during disposal operations (effluent) is a major environmental concern associated with such disposal.

Dredged material placed in a disposal area undergoes sedimentation that results in a thickened deposit of material overlaid by clarified water (called supernatant), which is discharged as effluent from the site during disposal operations. The concentrations of suspended solids in the effluent can be determined by column settling tests.

* The modified elutriate test does not account for long-term geochemical changes that may occur following disposal and subsequent drying of the dredged material and therefore should not be used to evaluate quality of surface runoff from the disposal site.

The effluent may contain both dissolved and particle-associated contaminants. A large portion of the total contaminant content is particle associated. The modified elutriate test was developed for use in predicting both the dissolved and particle-associated concentrations of contaminants in the effluent from confined disposal areas.

REGULATORY ASPECTS: Guidelines have been published to reflect the 1977 Amendments of Section 404 of the Clean Water Act (EPA 1980b). Proposed testing requirements define dredged material according to four categories. Category 3 includes potentially contaminated material proposed for confined disposal that has "potential for contamination of the receiving water column only." The proposed testing requirements call for evaluation of the short-term water-column impacts of disposal area effluents. Predicted contaminants levels based on results of modified elutriate and column settling tests along with operational considerations can be used with appropriate water-quality standards to determine the mixing zone required to dilute the effluent to an acceptable level (Environmental Effects Laboratory 1976, EPA/CE 1977).

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Initial Screening

An initial screening for contamination must be performed as outlined in the testing requirements for Section 404 of the Clean Water Act (EPA 1980b). The evaluation is designed to determine if there is reason to believe that the sediment contains any contaminant at a significant concentration (above background levels) and to identify the contaminants of concern that should be considered for analysis in the modified elutriate test. Considerations include but are not limited to:

- a. Potential routes by which contaminants could reasonably have been introduced to the sediment.
- b. Data from previous tests of the sediment or other similar sediment in the vicinity, provided comparison would still be appropriate.
- c. Probability of contamination from surface runoff.
- d. Spills of contaminants in the area to be dredged.
- e. Industrial and municipal waste discharges.

Modified Elutriate Test

The modified elutriate test should be conducted and appropriate chemical analyses should be performed as soon as possible after sample collection. The volume of elutriate sample needed for chemical analyses will depend on the

number and types of analyses to be conducted (Plumb 1981). Both dissolved and total concentrations of contaminants must be determined. The volume required for each analysis, the number of parameters measured, and the desired analytical replication will influence the total elutriate sample volume required. A 4-l cylinder is normally used for the test, and the supernatant volume available for sample extraction will vary from approximately 500 to 1,000 ml, depending on the sediment properties, settling times, and initial concentration of the slurry. It may be necessary to composite several extracted samples or use large-diameter cylinders to obtain the total required volume.

Apparatus

The following items are required:

- a. Laboratory mixer, preferably with Teflon shaft and blades.
- b. Several 4-l graduated cylinders. Larger cylinders may be used if large sample volumes are required. Nalgene cylinders are acceptable for testing involving analysis of metals and nutrients. Glass cylinders are required for testing involving analysis of organics.
- c. Assorted glassware for sample extraction and handling.
- d. Compressed air source with deionized water trap and tubing for bubble aeration of slurry.
- e. Vacuum or pressure filtration equipment, including vacuum pump or compressed air source and appropriate filter holder capable of accommodating 47-, 105-, or 155-mm-diam filters.
- f. Presoaked filters with 0.45- μ m pore-size diameter.
- g. Plastic sample bottles, 500-ml capacity for storage of water and liquid phase samples for metal and nutrient analyses.
- h. Wide-mouth 1-gal-capacity glass jars with Teflon-lined screw-type lids for sample mixing. These jars should also be used as sample containers when samples are to be analyzed for pesticide materials.

Prior to use, all glassware, filtration equipment, and filters should be thoroughly cleaned. Wash all glassware with detergent; rinse five times with tap water; place in a clean 10-percent (or stronger) HCl acid bath for a minimum of 4 hr; rinse five times with tap water; and then rinse five times with distilled or deionized water. Soak filters for a minimum of 2 hr in a 5-M HCl bath and then rinse 10 times with distilled water. It is also a good practice to discard the first 50 ml of water or liquid phase filtered. Wash all glassware to be used in preparation and analysis of pesticide residues using the eight-step procedure given EPA (1980a).

Test procedure

The step-by-step procedure for conducting a modified elutriate test, as shown in Figure 1, is given in the following paragraphs.

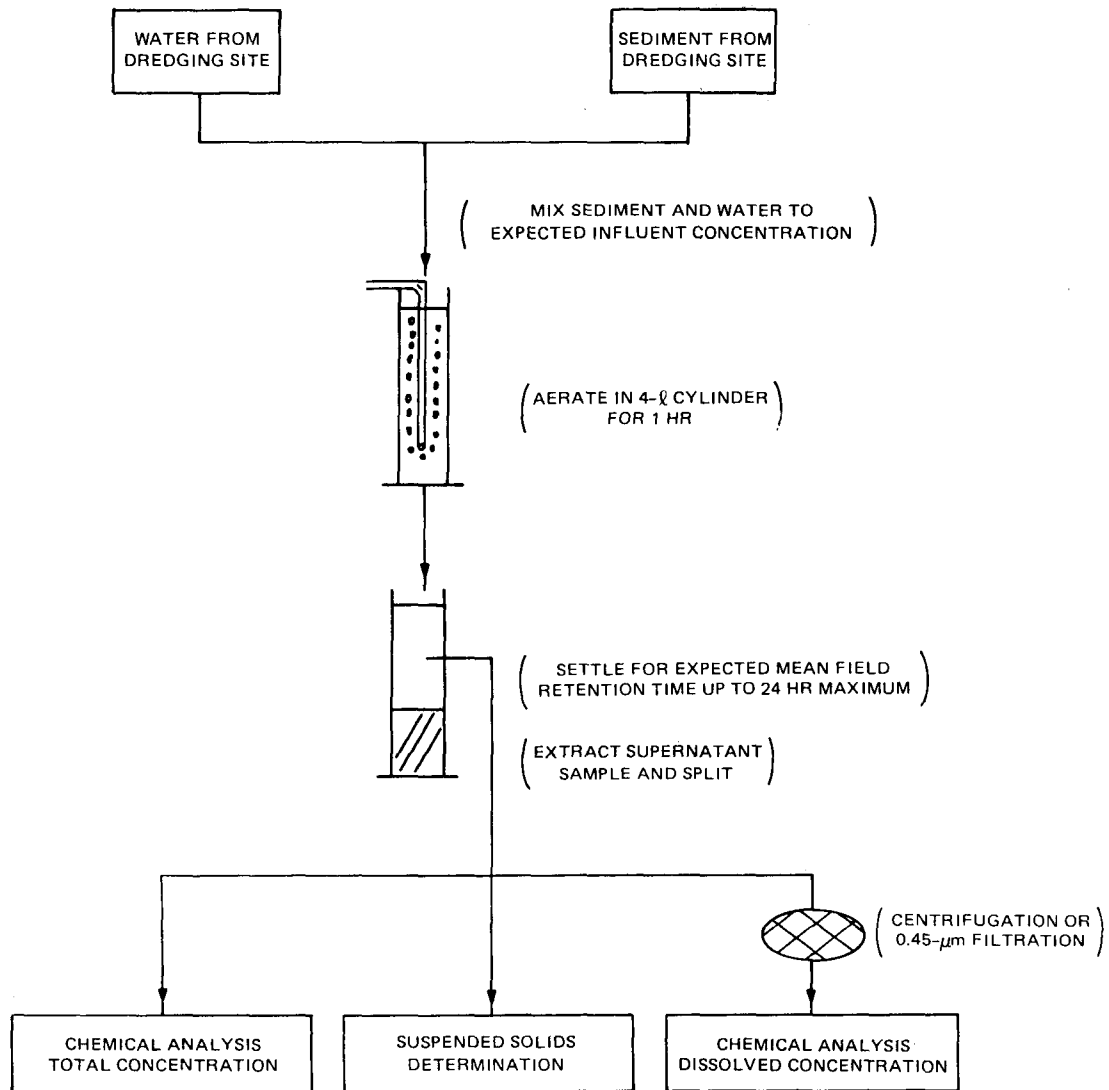


Figure 1. Modified elutriate test procedure

Step 1 - Slurry preparation. The sediment and dredging site water should be mixed to approximately equal the expected average field inflow concentration. If estimates of the average field inflow concentration cannot be made based on past data, a slurry concentration of 150 g/l (dry-weight basis) should be used. Predetermine the concentration of the well-mixed sediment in grams per liter (dry-weight basis) by oven drying a small subsample of known volume. Each 4-l cylinder to be filled will require a mixed slurry volume of 3-3/4 l. The volumes of sediment and dredging site water to be mixed for a 3-3/4-l slurry volume can be calculated using the following expressions:

and
$$V_{\text{sediment}} = 3.75 \frac{C_{\text{slurry}}}{C_{\text{sediment}}} \quad (1)$$

$$V_{\text{water}} = 3.75 - V_{\text{sediment}} \quad (2)$$

where

V_{sediment} = volume of sediment, liters

3.75 = volume of slurry for 4-l cylinder, liters

C_{slurry} = desired concentration of slurry, grams per liter
(dry-weight basis)

C_{sediment} = predetermined concentration of sediment, grams per liter
(dry-weight basis)

V_{water} = volume of dredging site water, liters

Step 2 - Mixing. Mix the 3-3/4 l of slurry by placing appropriate volumes of sediment and dredging site water in 1-gal glass jars and mixing for 5 min with a laboratory mixer. The slurry should be mixed to a uniform consistency with no unmixed agglomerations of sediment.

Step 3 - Aeration. Bubble aeration is used to ensure oxidizing conditions in the supernatant water during the subsequent settling phase. Pour the mixed slurry into a 4-l graduated cylinder. Attach glass tubing to the aeration source and insert tubing to the bottom of the cylinder. The tubing can be held in place by insertion through a predrilled No. 4 stopper placed in the top of the cylinder. Compressed air should be passed through a deionized water trap, through the tubing, and bubbled through the slurry. The flow rate should be adjusted to agitate the mixture vigorously, and bubbling should be continued for 1 hr.

Step 4 - Settling. Remove the tubing and allow the aerated slurry to undergo quiescent settling for a time period equal to the anticipated field mean retention time up to a maximum of 24 hr. If the field mean retention time is not known, allow settling for 24 hr. Guidance for estimating the field mean retention is given in Technical Note EEDP-04-3.

Step 5 - Sample extraction. After the settling period, an interface will usually be evident between the supernatant water with low concentration of suspended solids and the more concentrated settled material. Samples of the supernatant water should be extracted from the cylinder at a point midway between the water surface and the interface using syringe and tubing. Care should be taken not to resuspend settled material.

Step 6 - Sample preservation and analysis. The sample should be analyzed as soon as possible after extraction to determine the total suspended solids and the dissolved and total concentrations of selected constituents. The fraction of a constituent in the total suspended solids can then be calculated. Filtration using 0.45- μ m filters should be used to obtain subsamples for analysis of dissolved concentrations. Samples to be analyzed for dissolved pesticides or PCB must be free of particles but should not be filtered, due to the tendency for these materials to adsorb on the filter. However, particulate matter can be removed before analysis by high-speed centrifugation at 10,000 times gravity using Teflon, glass, or aluminum centrifuge tubes (Fulk et al. 1975). The total suspended solids concentration can also be determined by filtration (0.45 μ m). The fraction of a constituent in the total suspended solids is calculated as follows:

$$F_{SS} = (1 \times 10^6) \frac{C_{total} - C_{diss.}}{SS} \quad (3)$$

where

- F_{SS} = fraction of constituent in the total suspended solids, milligrams per kilogram of suspended solids
- C_{total} = total concentration of constituent, milligram per liter of sample
- $C_{diss.}$ = dissolved concentration of constituent, milligrams per liter of sample
- SS = total suspended solids concentration, milligrams per liter of sample

Subsamples for analyses of total concentrations should undergo appropriate digestion prior to analysis. All digestion and chemical analyses should be performed using accepted procedures (American Public Health Association 1985; EPA 1980a; and EPA 1979).

Samples to be analyzed for pesticides or PCB should immediately undergo solvent extraction. The extract may then be held in clean uncontaminating containers for periods up to three or four weeks at -15 to -20° C before further analyses are performed.

Samples for metals analysis should be preserved immediately by lowering the pH to <2 with 3 to 5 ml of concentrated nitric acid per liter (EPA 1979). High purity acid, either purchased commercially or prepared in a subboiling unit, must be used.

Nutrient analyses should be conducted as soon as possible. Acidification with H_2SO_4 to $\text{pH} < 2$ and storage at 4°C will allow the sample to be held for maximum of 24 hr for ammonia nitrogen, Kjeldahl nitrogen, and nitrate nitrogen analyses (EPA 1979). Storage at 4°C will allow holding of samples to be analyzed for dissolved orthophosphate and total dissolved phosphorus for up to 24 hr. Subsamples to be analyzed for cyanide should be preserved with 2 ml of 10 N sodium hydroxide per liter of sample ($\text{pH} > 12$) (EPA 1979).

Column Settling Test

Sedimentation tests, performed in 8-in.-diam ported columns as shown in Figure 2, are necessary to provide data for design or evaluation of disposal areas for retention of suspended solids. These tests were originally designed to define the settling behavior of a particular sediment and to provide information concerning the volumes occupied by newly placed layers of dredged material. The test procedures were modified to obtain data for use in predicting the concentration of suspended solids in the effluent.

Sedimentation of freshwater slurries of solids concentration less than 100 g/l can generally be characterized by flocculent settling properties. As solids concentrations exceed 100 g/l, the sedimentation process may be characterized by zone settling properties in which a clearly defined interface is formed between the clarified supernatant water and the more concentrated settled material. Zone settling properties also govern when the sediment/water salinity is greater than 3 ppt. Recent studies have shown that flocculent settling governs behavior of suspended solids in the clarified supernatant water above the sediment/water interface for slurries exhibiting an interface.

Apparatus

A settling column such as shown in Figure 2 is used. The test column depth should approximate the effective settling depth of the proposed disposal area. A practical limit on the depth of test is 6 ft. The column should be at least 8 in. in diameter with interchangeable sections and with sample port at 1-ft or closer intervals in the lower 3 ft and at 1/2-ft intervals in the upper 3 ft. The column should have provisions to bubble air from the bottom to keep the slurry mixed during the column filling period. Shop drawings for construction of the test columns are available from the Waterways Experiment Station.*

* Address request for the shop drawings to the attention of WESEP-E.

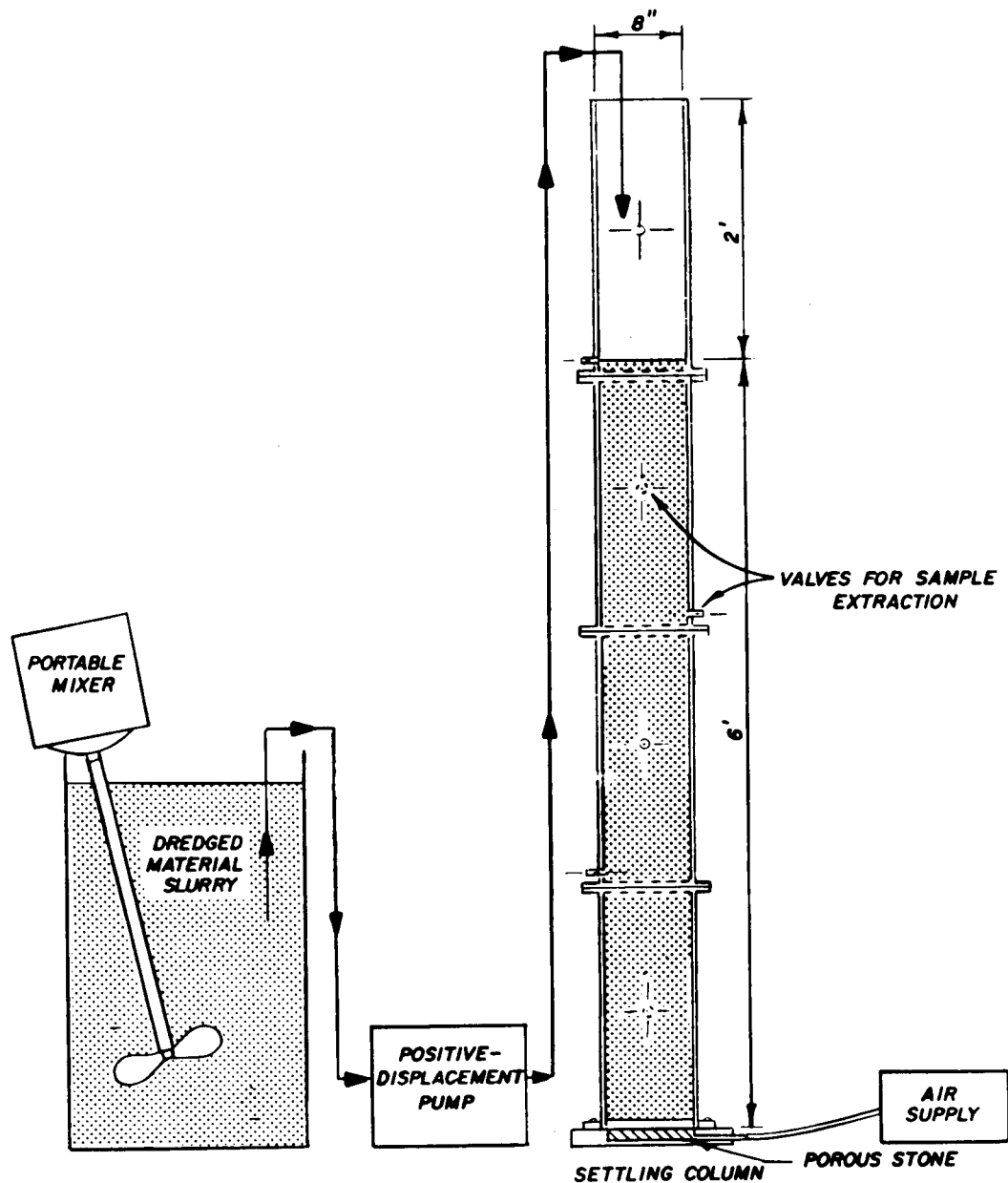


Figure 2. Schematic of apparatus for column settling tests (Montgomery 1978)

Flocculent settling test

Test data required to design or evaluate a disposal area in which flocculent settling governs and to predict the concentration of suspended solids in the effluent can be obtained using procedures described by Montgomery (1978) and Palermo, Montgomery, and Poindexter (1978). The flocculent settling test consists of withdrawing samples from each sample port at regular time intervals to determine the concentration of suspended solids at various depths.

Zone settling test

Information required to design or evaluate a disposal area in which zone settling governs can be obtained by conducting a series of zone settling tests (Montgomery 1978 and Palermo, Montgomery, and Poindexter 1978). One of the tests should be performed on sediment slurries at a concentration equal to the expected mean field inflow concentration. This test should be continued for a period of at least 15 days to provide data for estimating volume requirements and to obtain data for prediction of effluent suspended solids concentrations.

The procedures described below include those modifications of the procedures described by Montgomery (1978) and Palermo, Montgomery, and Poindexter (1978) required to define the flocculent process governing the sedimentation of suspended solids above the interface. The flocculent settling test as modified consists of measuring the concentration of suspended solids at various depths and time intervals by withdrawing samples from the settling column and timing the fall of liquid/solids interface.

Step 1 - Slurry preparation and loading. Mix the sediment slurry to the desired suspended solids concentration in a container with sufficient volume to fill the test column. The test should be performed at the concentration C_i selected to represent the anticipated concentration of the dredged material influent. Field studies indicate that for maintenance dredging in fine-grained material, the disposal concentration will average about 150 g/l. This value may be used for C_i if no better data are available.

Step 2 - Settling and sampling. For sediments exhibiting zone settling behavior, an interface will form between the more concentrated settled material and the clarified supernatant water. The first sample should be extracted immediately after the interface has fallen sufficiently below the uppermost port to allow extraction. This sample can usually be extracted within a few hours after initiation of the test, depending on the initial slurry concentration and the spacing of ports.

As the interface continues to fall, extract samples from all ports above the interface at regular time intervals. Substantial reductions of suspended solids will occur during the early part of the test, but reductions will lessen at longer retention times. Therefore, the intervals can be extended as the test progresses. A suggested sequence of intervals would be 2, 4, 8, 12, 24, 48, 96 hr, etc. Continue to take samples throughout the 15-day test or until the suspended solids concentration of the extracted samples shows no decrease. Record the time of extraction and the port height for each port sample taken (Figure 3).

(1) TIME t HR	(2) SAMPLE DEPTH z FT	(3) TOTAL SUSPENDED SOLIDS SS mg/l	(4) PERCENT OF INITIAL CONCENTRATION ϕ
3	0.2	93	
	1.0	169	
7	1.0	100	
	2.0	105	
14	1.0	45	
	2.0	43	
	3.0	50	
24	1.0	19	
	2.0	18	
	3.0	20	
48	1.0	15	
	2.0	7	
	3.0	4	

NOTES: COLUMNS 1 AND 2 - RECORD FOR EACH PORT SAMPLE.
 COLUMN 3 - COMPLETE FROM TEST RESULTS.
 COLUMN 4 - COMPUTE USING THE HIGHEST SUSPENDED SOLIDS CONCENTRATION OF
 THE FIRST PORT SAMPLE AS THE INITIAL CONCENTRATION SS_0 .

Figure 3

References

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